Comparison of spectral signature of Mg II h, k and Ca II K lines on a plage region

Tomoko Kawate (Queen's University Belfast), Kiyoshi Ichimoto (Kyoto U.),
Satoru UeNo (Kyoto U.), Ken'ichi Otsuji (NAOJ)

t.kawate@qub.ac.uk

Abstract

We performed a spectroscopic observation with Domeless Solar Telescope at Hida Observatory of Kyoto University in Japan. The obtained data are spectroheliogram in Ca II K, H-alpha and Ca II IR 8542 A of a plage region, and simultaneously observed with IRIS Mg II h, k. Comparing the difference of spectral manifestations of Mg II h, k and Ca II K, we found a fairly good correlation between intensities of Ca II K and Mg II h/k and their ratio is well understood by a plank function as if they are emitted from layers at same temperature. On the other hand there are significant deviations (by factor of 3) of Mg II h/k intensity from that inferred from the Ca II K intensity in pixel basis. This infers that Mg II h/k provides unique and additional information of the stratified atmosphere to that of Ca II K line.

Introduction

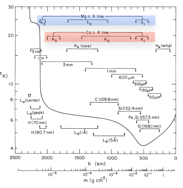

Fig.1 Vernazza et al . (1981)

Though IRIS has been providing very novel and interesting data of chromospheric and TR spectroscopy, interpretation of them, especially Mg II on disk, is difficult.
→ It has been said that the formation height of Ca II K is almost the same as Mg II, so that we can compare them to understand Mg II spectra.

Observations

Position: (236,311)
Target: plage region
Time: 2014-04-15 06:09-06:29 UT

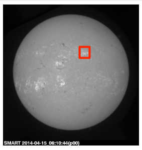

Fig.2 position of the target

*** Domeless Solar Telescope (DST)@ Hida Obs.**

- continuous raster scan x 88 scan
- cadence: 0.05s /step, ~8s+dead time(~4s) /raster
- spatial scale: 0.38"/pix, 0.68"/step
- spectral scale: 0.0149 A/pix
- Ca II K 3934, H-alpha 6563, Ca II 8542
- observers: Kawate, Ueno, Ichimoto

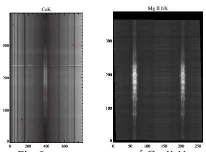

Fig.3 spectrogram of Ca II K and Mg II h/k

*** IRIS**

- Large sparse 64-step raster x 2 scan
- cadence: 9.2s /step, 587s /raster
- spatial scale: 0.33"/pix, 1.00"/step (NUV)
- spectral scale: 0.051 A/pix (NUV)

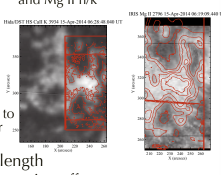

Fig.4 co-alignment to each other

preprocessing

- preparation of calibrated (λ, y, x) cube for each wavelength
- rebinning spatial sampling of DST data cube to freeze seeing effect
- spatial and temporal co-alignment and extraction of the spectra which were obtained on the same position and at the same time

→ 3571 spectra have remained

Theoretical aspect of Intensity

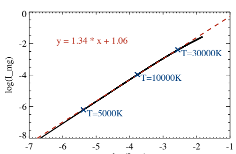

Fig.5 Intensity relationship under $T_{Ca} = T_{Mg}$

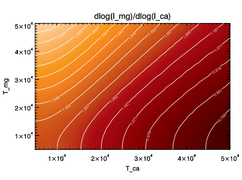

Fig.6 Intensity relationship in any T_{Ca} and T_{Mg}

Under the LTE and optically thick conditions, intensity is written by

$$I(\nu) \simeq \frac{2h\nu^3}{c^2} \frac{1}{e^{h\nu/kT} - 1}$$

If Ca II K (3900 A) and Mg II (2800 A) are formed at the same temperature layer, log I_{Mg} -log I_{Ca} scatters around the line of which inclination is **1.34**.

If the differential coefficient "d(log I_{Mg})/d(log I_{Ca}) " decrease as the Ca II K temperature increase, it can be interpret that the height of Mg II is smaller than Ca II K, or getting smaller relative to Ca II K.

Analyses and Results

1. Spectral features

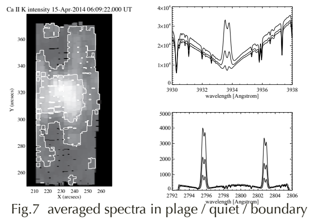

Fig.7 averaged spectra in plage / quiet / boundary region

Spectra of averaged plage/quiet/boundary region divided with the white line are shown in Fig.7. From this figure, we can see that K1 component in Ca II is very large in the quiet region, and relative red shift in the line core is rather smaller in Ca II K than Mg II.

2. Integrated line intensity

Integrated intensities over 1 A around each of line center (like a filtergraph) are shown in Fig.8. Each 2D histogram of the scatter plot shows a break between plage and quiet region. Because the power law index is 1.39 in Mg II h vs. Ca II K in plage region, they can be almost the same formation height while Mg II k is higher. However, in quiet region, the power law indices are high so that the formation height of Ca II K is much lower than Mg II. This may be because contribution of Ca II K1 is large in quiet region.

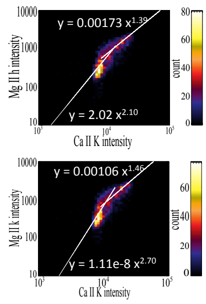

Fig.8 intensity relation in a filtergraph

3. Intensity of K2/K3

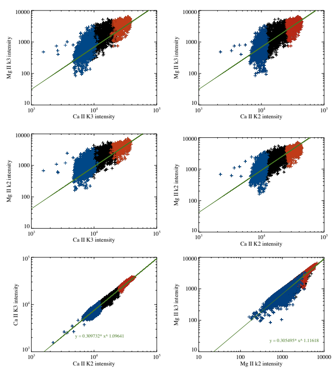

Fig.9 intensity relation of Ca II K2/K3 and Mg II k2/k3

Peak intensities of Mg II k2/k3 and Ca II K2/K3 are shown in Fig.9. **Green line** in Ca II K vs Mg II k plot shows $y \propto x^{1.34}$. Under the LTE and optically thick conditions, if Ca II K and Mg II k formed at the same height, scatter plot of intensity should be on this green line. These figures also show that plage and quiet region shows different inclination (power law index) between I_{Ca} and I_{Mg} and ,in plage region, Mg II k3 vs. Ca II K2 is almost on the green line, though Mg II k2 vs. Ca II K3 is almost on the green line in quiet region.

Discussions and Conclusions

Under the LTE and optically thick assumptions, effective temperatures of Ca II K2 and Mg II k2 can be almost the same especially in plage region. However with respect to Ca II K3 and Mg II k3, LTE and optically thick assumption should not be taken into account and, in that case, differential coefficients of intensities do not have to be 1.34 even if they are the same temperature. Furthermore, scattering effect and optical thickness cannot be ignored for more realistic atmospheric model.

On the other hand there are significant deviations (by factor of 3) of Mg II h/k intensity from that inferred from the Ca II K intensity in pixel basis. This would infer that Mg II h/k provides unique and additional information of the stratified atmosphere to that of Ca II K line.

LWS / HINODE / IRIS WORKSHOP @PORTLAND, NOVEMBER 2014